NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Ames Research Center
Intelligent Systems Division
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DRAFT
STATEMENT OF WORK
FOR
INTELLIGENT SYSTEMS RESEARCH AND DEVELOPMENT SUPPORT–2 (ISRDS-2)

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1.0 INTRODUCTION

The Intelligent Systems Division (hereafter, referred to as Code TI or the Division) is part of the Exploration Technology Directorate (Code T) at the NASA Ames Research Center. Code TI conducts scientific research, develops technologies, builds applications, and infuses and deploys advanced information systems technology into NASA missions and other federal government projects. This procurement is for research, development and infusion support services to assist that effort.

The Division is a major contributor to enabling intelligent software technology research and development for NASA in the Aeronautics Research Mission Directorate (ARMD); the Science Mission Directorate (SMD); the Office of Chief Technologist (OCT); and the newly formed Human Exploration and Operations Mission Directorate (HEOMD).

Programs supported by the Division include Aviation Safety, Fundamental Aeronautics, and Airspace Operations for ARMD; Airborne, Space and Earth Science data pipelines and analyses, and mission operations for SMD; evolving advanced space technology development and demonstration programs in OCT; Advanced Exploration Systems, Human/Robotic systems and other capability-driven programs being developed in HEOMD; the Center's Small Sat Research projects, in addition to a variety of NASA inter-center work agreements (e.g. with JSC MOD) for the Division to provide specialized software systems.

Laboratories are operated by Code TI for many of the scientific and engineering disciplines under the purview of the Division. Code TI maintains strong relationships with other U.S. government agencies, industrial organizations, and academic partners for the purposes of joint research and rapid technology transfer.

Code TI is composed of technology-based groups, each with expertise to support the above-listed Mission Directorates. The technologies currently emphasized are described in section 2.3 of the Scope of Work that follows. Projects are described in section 2.4 of the Scope of Work and may require participation across multiple technical groups.

The requirements to be performed are described in the following sections. Consequently, the contractor may be required to perform at locations other than Ames Research Center.

2.0 SCOPE OF WORK

The Contractor shall provide research support in the following research domains: artificial intelligence (AI), knowledge-based systems, knowledge discovery and data mining, soft computing (including neural networks and fuzzy control methods), information processing and sensors, biologically inspired computer systems and human extensions, prognostic signal analysis, model-based diagnostic reasoning, software fault diagnostic automated software methodologies, fault-tolerant computing hardware and networking, tele-presence and tele-control of remote, mobile platforms, autonomous and adaptive control, integrated design, human-centered computing, system design of a distributed heterogeneous network of workstations, and distribution of research information in various formats and forums.

The following descriptions represent the Government's best effort to project future research support requirements. Due to the research and development nature of Code TI's missions, the descriptions should not be regarded as definitive representations of future research support requirements.

The contractor shall be responsible for providing flexible, responsive, coordinated, and comprehensive research mission services that are adjustable within the framework of a series of individual Contract Task Orders (CTOs). The Government will use a task completion oriented CTO as the vehicle to acquire research and development from the contractor. Task orders will contain defined requirements (such as deliverables, significant milestone dates), negotiated cost/price information, and established performance measurement criteria.

The Contractor shall administer all work to be performed under this contract, and assure the availability of qualified personnel for timely response to negotiated CTOs. Individual task plans shall be negotiated and managed on a per task basis. For each task, technical progress and resource expenditures shall be reported monthly by the Contractor to the Government.

2.1 Contract Management

The Contractor shall provide overall management and administrative functions to ensure that the proper resources are available and allocated, that required reports and documentation are prepared, and that the overall environment supports the research requirements. The Contractor shall perform the following:

(1) Manage the contract in a fiscally responsible manner, fulfilling all requirements of negotiated CTOs.
(2) Provide a well-defined, stable organizational structure with clear lines of authority and clearly identified interfaces to the Government.
(3) Provide secretarial and financial services for their employees.
(4) Provide staff with training in state-of-the-art information technologies.

(5) Comply with Government policies and regulations including the Ames Management System (AMS) and relevant AMS policies (See Section 3.0)
(6) Manage the resources allocated by NASA for specific tasks in a manner to ensure research goals are reached in accordance with agreed upon milestones.
(7) Develop, implement and maintain a discrepancy reporting and tracking system. Discrepancy reports may be issued by the Contractor as well as by NASA regarding technical, resource or financial issues that may prevent meeting milestones or the performance of the task. The system shall assure that all discrepancies are documented and resolved. Discrepancy histories shall be reviewed for indications of systematic or recurring problems for future improvements that require correction.
(8) Provide a monthly report of the state of all tasks, identifying accomplishments, publications, and major milestones reached as well as problems and concerns over issues that may affect contract performance along with the recommended solutions.
(9) Provide property management to ensure accountability for installation-provided equipment and facilities and maintain responsibility for annual inventory surveys and accountability verification forms.
(10) Provide the risk management activities that will be used to ensure that the Government has adequate insight into the risks associated with the Contractor's ability to accomplish tasks outlined in any CTO.

2.2 Technical Task Support

It is anticipated that the Contractor staff shall perform the following functions as required on a per task order basis:

(1) Collaborate and exchange technical information with the Government research staff in order to meet the requirements of each CTO.
(2) Provide research support on a task-by-task basis, including direct research functions and indirect support such as technical and programmatic reviews.
(3) Provide short turn-around deliverables for specific project milestones as needed and within the time frame outlined in the approved CTO.
(4) Conform to all relevant standards and practices (configuration management, system integration requirements, etc.) for all projects and deliverables.
(5) Support technology infusion/deployment efforts with NASA customers.
(6) Attend and participate in group and project meetings.
(7) Present research, work in progress, and results to civil service management and at conferences.
(8) Support (occasionally short-notice) preparations for demonstrations and presentations of research, work in progress, and results to visitors and technical delegates, including supporting and/or hosting of technical workshops as needed.
(9) Travel as needed to conferences, field sites, universities, and other agencies in the performance of research, integration of products, technology infusion, and other important demonstration of results.

(10) Acquire resources (equipment, furnishings, supplies) needed to support the successful completion of all CTO and related work.

2.3 Technology Areas (CORE Research Areas)

The Intelligent Systems Division performs core research in four technology areas. As the research matures or as projects require, work from multiple areas can be matrixed to support a single task, project or program.

Technology Area 1: Autonomous Systems and Robotics (ASR)

The Contractor shall support the missions of the Autonomous Systems and Robotics groups, consisting principally of three main sub-areas: (a) planning and scheduling, (b) robotics, and (c) advanced control.

The Contractor will be involved in research, development, and deployment of automated reasoning methods and decision support methods for autonomous systems. Such work includes enabling the design, construction, simulation, and operation of a new generation of systems that can act autonomously, as well as in support of humans, while achieving more science return at much lower cost than current approaches. Autonomous systems require developing autonomous control kernels (commanded by high-level, goal-directed behaviors) that are programmable through compositional, common-sense models of hardware and operations behavior. Such systems also require developing on-board automation to close the loop on sensor information at the goal level, using advanced planning, scheduling, execution, diagnosis, and recovery capabilities to ensure that goals are met. Novel approaches to both inner- and outer-loop control, both continuous and discrete, are developed to enable robot, aircraft and spacecraft missions. Autonomous systems must take action to gain information, assess mission risk, plan contingencies, prepare backup resources, redirect plans to reduce risk, learn from their interactions with their environment, and adapt in real-time. Thus, the Contractor shall perform research and develop distributed coordination and collaboration capabilities that enable autonomous systems and humans to act as teams. This includes design, development, and deployment of the associated command and control systems and environments used to conduct mission planning, monitoring of remote autonomous systems, and interactions with those systems. Contractor staff may be tasked to support or participate in deployments and field campaigns to remote, austere sites, or to extended flight test activities at other Government sites.

The Contractor shall employ a broad range of Artificial Intelligence (AI) methods such as model-based reasoning and simulation, planning and scheduling, constraint-based reasoning, local and global optimization, decision theory, machine learning, intelligent synthesis, multi-agent coordination, and other innovative or traditional techniques to the missions and tasks. The Contractor will provide software development support with state of the art experience in C++, Java and other modern programming languages, and expertise in 3D visualization, user interface design, and associated development tools.

Technology Area 2: Collaborative & Assistant Systems (CAS)

The Contractor shall support the missions of the Collaborative and Assistant Systems projects. The Contractor will be involved in research, development, and deployment of methods that provide computer-based support for daily work activities of scientists, engineers, managers, and operational support personnel contributing to major NASA aeronautics and space Programs. The Contractor will be involved in research, development and operational sustainment activities that require analysis of work environments, technology needs, and communication patterns. The Contractor shall design and develop advanced collaboration, communication, and performance support systems, and deliver these on conventional and mobile computing platforms. The Contractor shall employ and integrate a broad range of technologies including collaborative systems design, groupware, work systems simulation, information indexing and retrieval, intelligent interfaces, adaptive systems, wireless technologies, information visualization, intelligent agents, data/information analysis techniques, knowledge-based systems, and other innovative or established technologies. The Contractor shall focus application efforts so as to satisfy mission requirements in major NASA programs such as Earth Sciences, Space Sciences, Human Exploration and Development of space, Space Operations, Airspace Systems and Aviation Safety and Security.

A recent example of such an application effort was the development of the Semantic Organizer distributed science and engineering support environment, a computer-supported cooperative work application. Such work involves both science and engineering code development, and the specification, design, development, and integration of codes for use by a science and engineering user community. The task thus includes substantial communication and interfacing with a broad range of users in order to understand the needs that drive development requirements, in addition to the development of the hardware and software systems to support the resultant application.

Technology Area 3: Discovery and Systems Health (DaSH)

The Contractor shall support the objectives of the Health Management Systems (diagnostics and prognostics); ISHM Technology Maturation; Modeling, Learning and Control; and Intelligent Data Understanding groups. The Contractor will be involved in research, development, and deployment of advanced software technology and methods for enhanced scientific and engineering data analysis, basic and applied knowledge discovery, and reduction of operational and lifecycle costs in major NASA aeronautics and exploration Programs. Advanced software technology includes the development of algorithms that support modeling, simulation, diagnosis, prognostics, data mining, analysis and display. Specific support will be in the development and deployment of advanced algorithms, such as model-based diagnosis, prognostic life estimation models, physics-based models, traditional machine learning, learning from partial or incomplete models, Bayesian and other statistical and model-based learning methods.

The Contractor shall be required to support the objectives of the Discovery and Systems Health research groups in applying these model-based and data-driven technologies toward the design of health management systems, ISHM systems engineering, sensor selection and optimization, monitoring, data analysis, prognostics, diagnostics, failure recovery, diagnostic decision aids, and data and knowledge management.

The main products from this technology area are advanced software tools and applications applicable to a wide range of internal NASA programs such as SLS, Ground Operations, Deep Space Habitat, Aviation Safety, Avionics Health State Assessment and Management and external activities including aviation security applications and spacecraft applications with other government agencies.

Technology Area 4: Robust Software Engineering (RSE)

The Contractor shall support the objectives of the Robust Software Engineering technical research area. The Contractor will be involved in research, development, and deployment of advanced software engineering tools into NASA missions. The technical research area has a long history of developing landmark advances in software engineering tools and case studies on NASA software. The emphasis will be on maturation and adaptation of the tools so they can be incorporated directly into the software development and verification process and validation used in different NASA missions. In order to do this, the tools will need to be adapted to interoperate with specific commercial tools already chosen within targeted NASA projects. For example, Project Orion, the Multi-Purpose Crew Vehicle (MPCV) Flight Dynamics Team (FDT) is using commercial autocoding tools Simulink, Stateflow, and Embedded Coder tools as key parts of the software development chain. Interfacing to these commercial tools is essential in order to have RSE tools for test-case generation, autocode verification, and model analysis adopted by Project Orion.

To support the goals of RSE, the Contractor shall provide:

- Model analysis (includes former compositional verification and aspects of previous formal methods)
- Autocode verification (formerly Program Synthesis)
- Automated verification and validation (V&V).
- Advanced testing
- Mathematical approaches to program verification
- Software design verification
- Software engineering
- Static program analysis

The main products expected are advanced software tools. The Contractor shall report research results in appropriate technical journals, and at conferences and workshops.

2.4 Mission Operations

Ames Research Center has successfully designed, built and flown a number of spacecraft, both small and large, dating back to Pioneer in the 1960s and Lunar Prospector in the late 1990s. In recent years, Ames has flown Small Spacecraft Missions, such as GeneSat and PharmaSat, as well as full-scale spacecraft, such as LCROSS and Kepler and the upcoming LADEE and IRIS missions. In addition, it also supports operation of ISS and STS payloads and science instrumentation, such as EMCS, and SPHERES. Ames employs experienced project management, flight operations teams, and has a proven multi-mission operations center.

2.4.1 Flight Operations Office

Ames specializes in the development and execution of innovative low-cost flight operations. Ames flight teams draw from a broad range of experience leading or collaborating on heliocentric, planetary, lunar, and earth orbiting science and exploration missions. Ames collaborations with other flight centers on manned missions' further augments their experience base. With operations exposure over the full range of mission risk classifications (class D through A), Ames staff are uniquely postured to leverage the best mix of skills and lessons learned to each mission it performs.

In house skills cover the full range of flight operations capabilities. These skills include Mission Design, Mission Planning, Mission Operations Management, Spacecraft System Engineering, Command Planning and Sequencing, Spacecraft Command and Telemetry Processing, Communications Design and Link Management, Spacecraft Simulation Testbed Development and Operation, Ground System Development, Ground System Management, Science Payload Development and Operation, and Flight Dynamics (Orbit Determination, Navigation, Attitude and Maneuver Design).

Ames flight operations teams maintain a healthy working relationship with other flight centers. For example, the Ames LCROSS mission flight team Mission Maneuver and Design subsystem worked with JPL and GSFC for navigation, orbit determination and TCM attitude planning, and with JPL for DSN scheduling. The Ames LADEE mission flight team will perform these tasks in-house at Ames, but will integrate a Science Operations Center at GSFC. The Ames IRIS mission flight team will integrate a science operations center at Lockheed. Ames flight teams continue to look to the NASA centers for expertise and partnerships wherever it is most cost effective and beneficial to the mission and NASA.

Many of the Ames Flight Operations staff gained their trained and experience through participation on flight projects and programs with JPL, JSC, GSFC, KSC and MSFC. Ames continues to pursue these flight operations collaborations.

2.4.2 Multi-Mission Operations Center

The Ames Multi-Mission Operations Center (MMOC) enables and supports flight and science operations for Ames spaceflight missions. The MMOC is composed of the facilities, networks, IT equipment, software, and support services needed by flight projects to effectively and efficiently perform all mission functions, including planning, scheduling, command, telemetry processing, and science analysis.

The MMOC facilities and data systems are FISMA-compliant and were granted authority to operate in August 2007. The facilities include two general-purpose Mission Operations Centers (MOC-1 and MOC-2), the Kepler Science Operations Center (KSOC), and the SOFIA Science Center. The current capacity of the MMOC ranges up to four simultaneous missions, dependent upon mission size and complexity, and resources exist to support future expansion.

Missions utilizing the MMOC have access to voice loops connecting all NASA flight centers. Live video streams from launch operations at the Cape and from the International Space Station are also available. Data processing capabilities include telemetry and science data handling, storage, distribution, and archiving. Telemetry and science data can be distributed real-time via secure, dedicated network links. Select data can also be made available via the Internet. The MMOC enables ground data systems interfaces to ground support equipment, including hardware-in-the-loop simulators. When required, the MMOC can implement system redundancy to achieve high operational availability.

The MMOC is configurable to support use of the software tools that each mission requires. Command and telemetry handling software deployed in the MMOC include ASIST and ITOS, but any similar application can be accommodated. Currently, the MMOC is implementing the GMSEC modular software architecture so that various command and telemetry applications can be easily plugged in.

Mission support services performed by the MMOC staff include network engineering to define and activate connections not only to the spacecraft, but also to mission partners at other NASA centers, in industry and in academia. The staff will administer and maintain all mission IT equipment and databases. Physical and IT security is monitored and enforced to protect mission resources, both equipment and data.

2.5 Software Systems Engineering and Software Project Management

In addition to being a fundamental research organization, the Division will also develop and deploy applications to customers at other NASA Centers, other Federal agencies, and industry. These applications are infusions of technology developed through Division research. The focus of this area is to apply standard engineering practices to deliver reliable applications, within schedule, and within budget. Current recipients of Division technology infusion include:

1. The ARC **Small Spacecraft Office** (SSO) develops, launches, and operates small space missions using a low-cost methodology. The

objective is to develop missions in less time, at lower cost, and capable of delivering highly useful scientific and technical payloads in order to aid future NASA missions. One of the primary goals is to develop the capability within NASA to have space vehicles that could be deployed faster and cheaper than conventional spacecraft today in order to expand the number of flight opportunities and to take advantage of the latest technologies through shorter development cycles. In order to achieve low cost access to space, the SSO looks at alternative launch vehicles, as well as hardware developed under past and current Department of Defense (DoD) investments.

The activities of the Small Spacecraft Office include technology evaluation, proposal development, spacecraft hardware development, and mission implementation and operations. The SSO evaluates technology and processes that can enable low-cost spacecraft development, such as structures, avionics, sensors, flight software, propulsion, integration and testing, and mission operations. These components are used to develop full mission proposals that, if selected, could lead to mission development projects. Current projects include earth orbiting nano- and micro-spacecraft, as well as deep-space spacecraft bus designs.

2. Johnson Space Center **Mission Operations Directorate (MOD)** projects –
   a. Solar Array Constraint Engine (SACE) – assists the Power, Heating, Articulation, Lighting and Control (PHALcon) flight controllers to manage the orientation and operation of the new ISS solar arrays.
   b. Inductive Monitoring System (IMS) – monitor and compare the multiple telemetry streams from the ISS control moment gyros to provide decision support.
   c. Scheduling, Training Administration, and Record (STAR) – develops replacement tool suites for the management of training space flight crews and flight controllers as well as the scheduling of heavily constrained resources across mission operations.

3. NASA/NOAA-GOES-R Ground Segment Project non-advocate assessment.

   Software Non-Advocate Assessment is performed only on critical software that is safety or security critical, and/or software that is necessary for spacecraft operations. Assessment activities will revolve around three components: requirements analysis, design analysis and implementation analysis

   Assessment is performed on Mission Management (MM), and for software generating and delivering Key Performance Parameters (KPPs) to the Advanced Weather Interactive Processing System (AWIPS) performed within the Product Generation (PG) and Product Distribution (PD) elements. Critical software includes both developmental software (software to be developed under the GOES-R GS project) and non-developmental software

such as off the shelf products and OTS products that require customization for use in GOES-R GS.

4. Lunar Atmosphere and Dust Environment Explorer (LADEE) Mission Operations Systems (MOS) and Flight Software (FSW) – The LADEE mission will address science goals by examining the Moon's atmosphere and dust in the Moon's vicinity. The Division leads development and operation of the LADEE Mission Operations and Ground Data Systems, as well as the development of the flight software that will be used to operate the spacecraft. The latter includes development and deployment of model-based simulations of the spacecraft and subsystems, and associated software-development and simulation infrastructure.

In order to successfully support the development and deployment of division technologies in these areas, expertise will be required in:

(1) system architecture design
(2) system configuration definition and implementation
(3) security requirements during the system design
(4) integration of project systems into the division facility
(5) development and design of laboratories and testbeds for the various technologies
(6) network management of infrastructure to support project requirements
(7) security plan development for systems and projects
(8) configuration and security control of real time operating systems
(9) setup and configuration of avionics hardware testbed platforms
(10) security and customization of embedded operating systems and micro-kernels
(11) application of and compliance with NASA software engineering process requirements and standards, including but not limited to NASA Procedural Requirement 7150.2 Software Engineering, NASA NASA-STD-8739.8 Software Assurance and NASA-STD-8719.13B Software Safety
(12) application of CMMI Maturity Level 2-3 Processes as called for by NASA Software Engineering requirements

The Contractor shall be responsible for communicating knowledge about division technologies to technical and non-technical audiences as required by division projects. This communication includes the design, development and distribution of informational products in a wide variety of output formats including written, graphical, and electronic media, and live or static demonstrations.

Contractors working within this group shall perform the following tasks:

(1) Technical writing and editing
(2) Web site content development and maintenance
(3) Interfacing with technology groups to develop project requirements and acquire data
(4) Collect, format and distribute highlight reports to line and program management

(5) Compile and update research portfolios for line and program management

3.0 QUALITY ASSURANCE

In support of CTOs issued, the Contractor shall comply with the technical and management process requirements of the Ames Management System. This includes following applicable Ames' procedures that are subject to audit and preparing for and participating in process audits as required by Center and Agency authorities. The Contractor shall attend relevant training, provided by the Government, as required for all on-site employees. Specific procedures will be indicated on each task order response. These procedures include, but are not limited to, the following AMS documents:

NPD 1280.1	NASA Management Systems
APR 1280.1	Ames Management System (AMS)
NPD 8730.5	NASA Quality Assurance Program Policy

The Ames' Quality System documents can be found at: http://ams.arc.nasa.gov

4.0 DELIVERABLES

Products and services requirements shall be defined in each task order.

5.0 PHASE-IN/PHASE-OUT

Phase-In: The phase-in process shall be accomplished as expeditiously as possible, with a maximum phase-in period of 30 days. The phase-in process shall not adversely impact the work being done by the outgoing contractor. It shall be conducted in a manner consistent with safe operation requirements. The incoming contractor is responsible for providing a qualified contractor staff by the end of the phase-in period.

Phase-Out: Upon completion of this contract, the outgoing contractor is responsible for the orderly transfer of duties and records to the incoming contractor. This should be accomplished in an expeditious manner, consistent with any contract phase-in schedule, while minimally impacting ongoing task orders. The contractor shall submit a phase-out plan no later than 60 days before the end of the contract for Government review and approval.

APPENDIX

Definitions

- AI: Artificial Intelligence.
- AES: Advanced Exploration Systems (HEOMD Program)
- ARC: NASA's Ames Research Center, Moffett Field, California
- ARMD: Aeronautics Research Mission Directorate
- CO: Contracting Officer, the primary point of contact between the contractor and the Government
- COTR: The Contracting Officer's Technical Representative, charged with providing the CO with technical information and assessments about the contract
- CSO: Computer Security Official
- CTOs: Contract Task Orders.
- DOD: Department of Defense
- FSO: Flight Software Office
- GFE: Government Furnished Equipment
- HEOMD: Human Exploration and Operations Mission Directorate
- HET: Human Exploration Telerobotics (HEOMD Program)
- HRS: Human Robotics System (HEOMD Program)
- IMS: Inductive Monitoring System
- ISRDS: Intelligent Systems Research and Development Support
- IT: Information Technology
- ITRDO: Information Technology Research, Development, and Operations
- JSC: NASA Johnson Space Center
- MMOC: Multi Mission Operations Center
- MOD: Mission Operations Directorate
- MOS: Mission Operations Systems
- NASA: National Aeronautics and Space Administration
- OCT: Office of Chief Technologist
- POC: Point of contact – the designated contact person
- SACE: Solar Array Constraint Engine
- SMD: Science Mission Directorate
- SMO: Software Management Office
- SOW: Statement of Work
- SSO: Small Spacecraft Office
- ST: Space Technology (OCT Program)

- STAR: Scheduling, Training Administration, and Records
- VSE: Vision for Space Exploration